

WHAT IS CLAIMED IS:

1. In a network including a first node and a second node, a method for regulating a frequency deviation of an oscillator in the first node comprising the steps of:

- 5 receiving a time stamp message at the second node from the first node;
transmitting a reply time stamp message from the second node to the first node, wherein the reply time stamp message includes a time of transmission of the reply time stamp message and the second node's estimation of a time interval; and
calculating an estimated frequency deviation of the oscillator in the first
10 node using the second node's estimation of the time interval in the reply time stamp message.

2. The method of claim 1, further comprising the step of:
adjusting the oscillator in the first node using the calculated estimated frequency deviation.

- 15 3. The method of claim 1, wherein the time interval is a time period between the transmission of two time stamp messages between the first and second nodes.

4. The method of claim 1, further comprising the steps of:
estimating, in the first node, an absolute time of the transmission of the
20 time stamp message from the first node to the second node; and
transmitting another time stamp message from the first node to the second node, wherein the another time stamp message includes the estimated absolute time of transmission of the time stamp message and an uncertainty value as to the

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accuracy of the estimated absolute time of transmission of the time stamp message.

5. The method of claim 4, wherein the uncertainty value of the estimated absolute time is calculated using a Kalman observer.

5 6. The method of claim 4, further comprising the step of:
estimating a variance of a transmission delay of the network, wherein the uncertainty value of the estimated absolute time is increased by the variance of the estimated transmission delay.

7. The method of claim 4, further comprising the steps of:
10 estimating, in the second node, the absolute time of the transmission of the time stamp message from the first node to the second node; and
determining, in the second node, whether to use the first node's estimation of the absolute time in the determination of the time deviation of the oscillator of the second node as a function of the first node's estimation of the absolute time,
15 an uncertainty value of the first node's estimation of the absolute time, the second node's estimation of the absolute time and the uncertainty value of the second node's estimation the absolute time.

8. The method of claim 1, further comprising the steps of:
20 transmitting a plurality of time stamp messages from the first node to the second node;
receiving a plurality of reply time stamp messages at the first node; and
estimating a network delay and a variance of the network delay using a time of transmission of each of the plurality of time stamp messages and a time of
25 reception of each of the plurality of time stamp messages.

9. The method of claim 8, wherein the estimated network delay and the variance of the estimation network delay are used to establish a confidence interval which indicates whether a time stamp message was stuck in the network.

5 10. The method of claim 1, wherein the reply time stamp message also includes an uncertainty value of the estimation of the time interval, and the uncertainty value is a factor in the step of calculating the estimated frequency deviation.

11. The method of claim 10, wherein the uncertainty value of the estimation of the time interval is calculated using a Kalman observer.

10 12. The method of claim 10, further comprising the step of:
estimating a variance of a transmission delay for the network, wherein the uncertainty value of the estimation of the time interval is increased by the variance of the transmission delay.

15 13. The method of claim 1, further comprising the steps of:
receiving another time stamp message at a third node;
transmitting another reply time stamp message from the third node to the first node, wherein the another reply time stamp message includes a time of transmission of the another reply time stamp message and the third node's estimation of another time interval; and
20 calculating the estimated frequency deviation of the oscillator in the first node using the second node's estimation of the time interval and the third nodes estimation of the another time interval.

14. The method of claim 13, wherein the time interval is a time period between the transmission of two time stamp messages between the first node and second node, and the another time interval is a time period between the transmission of two time stamp messages between the first node and the third node.

15. The method of claim 13, wherein the first node, the second node and the third node are one group in a grouped network, the method further comprising the step of:

exchanging time stamp messages between the first node and another node, the another node being part of another group in the grouped network.

16. The method of claim 13, wherein the first node is a time server in an Internet Protocol network.

17. The method of claim 1, wherein the first node or the second node is a radio base station.

18. The method of claim 1, wherein the time of transmission on a physical layer is included in the reply time stamp message.

19. The method of claim 1, wherein the time stamp message includes a first sub-message and a second sub-message, the first sub-message containing a sequence number and the second sub-message containing the sequence number and a time of transmission of the first sub-message.

20. A network comprising:
a node including:
an oscillator;
means for receiving time stamp messages; and
5 a Kalman observer for determining a frequency deviation of
the oscillator using information in a received time stamp message.

21. The network of claim 20, wherein the node further comprises:
means for transmitting reply time stamp messages, the reply time stamp
messages containing a time of transmission, a time elapsed since a previous time
10 stamp message was transmitted, and an uncertainty value as to the accuracy of the
time elapsed since the previous time stamp message was transmitted.

22. The network of claim 21, wherein the node further comprises:
means for placing the time of transmission on a physical layer in the reply
time stamp message.

23. The network of claim 22, wherein the means for placing the time of
15 transmission in the reply time stamp message is a media access controller.

24. The network of claim 23, wherein the network is a ethernet
network.

25. The network of claim 20, further comprising:
20 a second node; and
a third node including an accurate time or frequency reference.

26. The network of claim 25, further comprising:
a switch between the third node and the first and second nodes, wherein
time stamp messages are sent from the third node to the node and the second
node.

5 27. The network of claim 26, wherein the network operates according
to an ethernet protocol.

28. The network of claim 27, wherein time stamp messages which are
delayed in the network more than a predetermined amount of time are discarded
by a node receiving the delayed time stamp messages.

10 29. The network of claim 25, wherein the Kalman observer determines
the frequency deviation of the oscillator using time stamp messages received from
the third node and the Kalman observer determines an absolute time for the node
using time stamp messages received from the second node.

15 30. The network of claim 29, wherein the node, the second node and
the third node are a group in a grouped network, and wherein the second node
contains a second oscillator and the third node contains a third oscillator, whereby
a frequency drift of the oscillator in the node is the same as a frequency drift of
the second and third oscillators.

20 31. The network of claim 25, wherein the accurate time or frequency
reference is a global positioning satellite (GPS) receiver.

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項目	単位	1990年	1991年	1992年	1993年	1994年	1995年	1996年	1997年	1998年	1999年	2000年	2001年	2002年	2003年	2004年	2005年	2006年	2007年	2008年	2009年	2010年	2011年	2012年	2013年	2014年	2015年	2016年	2017年	2018年	2019年	2020年	2021年	2022年	2023年	2024年	2025年	2026年	2027年	2028年	2029年	2030年	2031年	2032年	2033年	2034年	2035年	2036年	2037年	2038年	2039年	2040年	2041年	2042年	2043年	2044年	2045年	2046年	2047年	2048年	2049年	2050年	2051年	2052年	2053年	2054年	2055年	2056年	2057年	2058年	2059年	2060年	2061年	2062年	2063年	2064年	2065年	2066年	2067年	2068年	2069年	2070年	2071年	2072年	2073年	2074年	2075年	2076年	2077年	2078年	2079年	2080年	2081年	2082年	2083年	2084年	2085年	2086年	2087年	2088年	2089年	2090年	2091年	2092年	2093年	2094年	2095年	2096年	2097年	2098年	2099年	2100年																																																																		
総人口	人	12,128,000	12,240,000	12,350,000	12,460,000	12,570,000	12,680,000	12,790,000	12,900,000	13,010,000	13,120,000	13,230,000	13,340,000	13,450,000	13,560,000	13,670,000	13,780,000	13,890,000	14,000,000	14,110,000	14,220,000	14,330,000	14,440,000	14,550,000	14,660,000	14,770,000	14,880,000	14,990,000	15,100,000	15,210,000	15,320,000	15,430,000	15,540,000	15,650,000	15,760,000	15,870,000	15,980,000	16,090,000	16,200,000	16,310,000	16,420,000	16,530,000	16,640,000	16,750,000	16,860,000	16,970,000	17,080,000	17,190,000	17,300,000	17,410,000	17,520,000	17,630,000	17,740,000	17,850,000	17,960,000	18,070,000	18,180,000	18,290,000	18,400,000	18,510,000	18,620,000	18,730,000	18,840,000	18,950,000	19,060,000	19,170,000	19,280,000	19,390,000	19,500,000	19,610,000	19,720,000	19,830,000	19,940,000	20,050,000	20,160,000	20,270,000	20,380,000	20,490,000	20,600,000	20,710,000	20,820,000	20,930,000	21,040,000	21,150,000	21,260,000	21,370,000	21,480,000	21,590,000	21,700,000	21,810,000	21,920,000	22,030,000	22,140,000	22,250,000	22,360,000	22,470,000	22,580,000	22,690,000	22,800,000	22,910,000	23,020,000	23,130,000	23,240,000	23,350,000	23,460,000	23,570,000	23,680,000	23,790,000	23,900,000	24,010,000	24,120,000	24,230,000	24,340,000	24,450,000	24,560,000	24,670,000	24,780,000	24,890,000	25,000,000	25,110,000	25,220,000	25,330,000	25,440,000	25,550,000	25,660,000	25,770,000	25,880,000	25,990,000	26,100,000	26,210,000	26,320,000	26,430,000	26,540,000	26,650,000	26,760,000	26,870,000	26,980,000	27,090,000	27,200,000	27,310,000	27,420,000	27,530,000	27,640,000	27,750,000	27,860,000	27,970,000	28,080,000	28,190,000	28,300,000	28,410,000	28,520,000	28,630,000	28,740,000	28,850,000	28,960,000	29,070,000	29,180,000	29,290,000	29,400,000	29,510,000	29,620,000	29,730,000	29,840,000	29,950,000	30,060,000	30,170,000	30,280,000	30,390,000	30,500,000	30,610,000	30,720,000	30,830,000	30,940,000	31,050,000	31,160,000	31,270,000	31,380,000	31

37. In a network, a method of regulating an oscillator in a node comprising the steps of:

transmitting a time stamp message from a first node to a second node, wherein the time stamp message includes the first node's estimate of a time interval;

estimating, in the second node, the time interval; and

adjusting a frequency of an oscillator in the second node using the first node's estimate of the time interval and the second node's estimate of the time interval.

38. The method of claim 37, further comprising the step of:

calculating an uncertainty value for the second node's estimate of the time interval,

wherein the time stamp message includes an uncertainty value of the first node's estimate of the time interval, and the frequency of the oscillator in the second node is adjusted using the uncertainty value for the first node's estimate and the uncertainty value of the second node's estimate in addition to the first and second nodes' estimate of the time interval.

39. The method of claim 38, further comprising the step of:

determining, in the first node, whether to use the second node's estimation of the first time interval in the determination of the frequency deviation of the oscillator of the first node as a function of the first node's estimation of the first time interval, the uncertainty value of the first node's estimation of the first time interval, the second node's estimation of the first time interval and the uncertainty value of the second node's estimation of the first time interval.

40. The method of claim 39, further comprising the step of:
triggering an alarm, in the first node, if it is determined that the second
node's estimation of the first time interval is outside of a confidence interval.

41. The method of claim 37, further comprising the steps of:
5 transmitting a reply time stamp message from the second node to the first
node, wherein the reply time stamp message includes the second node's estimate
of the time interval and an uncertainty value as to the second node's estimate of
the time interval;

10 determining an uncertainty value for the first nodes estimate of the time
interval; and

adjusting the frequency of an oscillator in the first node using the first and
second nodes' estimate of the time interval and the uncertainty values of the first
and second nodes' estimate of the time interval.

42. The method of claim 37, further comprising the step of:
15 calculating an uncertainty value of the first node's estimate of the time
interval and the second node's estimate of the time interval, wherein the estimates
of the time interval and the uncertainty values of the nodes' estimate of the time
interval is performed using a Kalman observer; and

20 determining a frequency drift of the oscillator in the second node using a
Kalman observer based on the first node's estimate of the time interval, the
uncertainty value of the first node's estimate of the time interval, the second
node's estimate of the time interval and the uncertainty value of the second node's
estimate of the time interval, wherein the frequency of the oscillator in the second
node is adjusted based on the determined frequency drift.

Cont

43. A network including a first node, a second node and a third node, a method for oscillator regulation comprising the steps of:

estimating, in the first node, the length of time of a first time interval and the length of time of a second time interval;

5 receiving, in the first node, a time stamp message from the second node, wherein the time stamp message includes the second node's estimation of the first time interval;

10 receiving, in the first node, a time stamp message from the third node, wherein the time stamp message includes the third node's estimation of the second time interval; and

determining a frequency deviation of the oscillator of the first node based on the first node's estimation of the first and second time intervals, the second node's estimation of the first time interval and the third node's estimation of the second time interval.

15 44. The method of claim 43, further comprising the step of:

calculating, in the first node, an uncertainty value of the first node's estimation of the first time interval and an uncertainty value of the first node's estimation of the second time interval,

20 wherein the time stamp message from the second node also includes an uncertainty value of the second node's estimation of the first time interval,

wherein the time stamp message from the third node also includes an uncertainty value of the third node's estimation of the second time interval, and

25 wherein the step of determining the frequency deviation of the oscillator of the first node is also based on the first node's uncertainty value of the first node's estimation of the first and second time intervals, the second node's uncertainty value of the second node's estimation of the first time interval and the uncertainty value of the third node's estimation of the second time interval.

45. The method of claim 44, wherein the uncertainty values of the first node's estimation of the first and second time intervals are determined using a Kalman observer.

46. The method of claim 44, further comprising the step of:
5 determining, in the first node, whether to use the second node's estimation of the first time interval in the determination of the frequency deviation of the oscillator of the first node as a function of the first node's estimation of the first time interval, the uncertainty value of the first node's estimation of the first time interval, the second node's estimation of the first time interval and the uncertainty
10 value of the second node's estimation of the first time interval.

47. The method of claim 44, further comprising the step of:
sending an alarm, from the first node, to an operator of the second node if
it is determined that the second node's estimate of the time interval with the
uncertainty value of the second node's estimate of the time interval is more than a
15 predetermined amount different from the first node's estimate of the time interval with the uncertainty value of the first node's estimate of the time interval.

48. The method of claim 47, wherein the first node includes a global positioning satellite (GPS) receiver.

49. The method of claim 46, wherein the first node includes a global
20 positioning satellite (GPS) receiver, the method further comprising the steps of:
comparing the first node's estimate of the first time interval with the second node's estimate of the first time interval; and
discarding, in the first node, the second node's estimate of the first time interval if the second node's estimate of the first time interval is more than a

predetermined time longer or shorter than the first node's estimate of the first time interval and the uncertainty value of the second node's estimate of the first time interval is greater than the uncertainty value of the first node's estimate of the first time interval.

5 50. The method of claim 43, further comprising the step of:
 estimating, in the second node, an absolute time of a predetermined event,
 wherein the time stamp message received in the first node includes the estimation
 of the absolute time of the predetermined event.

10 51. The method of claim 50, wherein the predetermined event is a
 beginning of transmission of the time stamp message sent from the second node to
 the first node.

15 52. The method of claim 50, further comprising the steps of:
 determining an uncertainty value of the second node's estimation of the
 absolute time of the predetermined event;
 estimating, in the first node, the absolute time of the predetermined event;
 and

20 determining an uncertainty value of the first node's estimation of the
 absolute time of the predetermined event, wherein the first node's estimation of
 the absolute time, the uncertainty value of the first node's estimation of the
 absolute time, the second node's estimation of the absolute time and the
 uncertainty value of the second node's estimation of the absolute time is used to
 update a time reference in the first node and a time reference in the second node.